

Description

Voltage intermediate circuit converter

- 5 The invention relates to a voltage intermediate circuit converter as claimed in the precharacterizing clause of claim 1.

- 10 A converter such as this is known from German magazine "etz", Issue 20, 1998, pages 10 to 12. This known voltage intermediate circuit converter has, in the standard version, a 12-pulse diode rectifier, whose diode rectifier elements are each connected to a secondary winding of a three-winding transformer. On the DC-side,
- 15 the diode rectifier elements are each linked to a capacitor in a voltage intermediate circuit, which has two capacitors which are connected electrically in series. Such an input converter is also referred to as a diode front end (DFE). In most cases, such a diode front
- 20 end satisfies the requirements for the mains system power factor and harmonic content. If mains feedback effects are subject to more stringent requirements, then a 24-pulse input converter is available.

- 25 A voltage intermediate circuit converter which has a self-commutated pulse-controlled converter as the input converter is known from German magazine "Engineering and automation", Issue 1-2, 1998, pages 8 and 9. Like the machine-side pulse-controlled converter, this is in the
- 30 form of a three-point pulse-controlled converter. The voltage intermediate circuit is formed by two capacitors which are electrically connected in series. This input converter circuit option is also referred to as an active front end (AFE). An active front end allows four-quadrant

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operation (driving and regenerative braking in both
rotation directions). This

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active input converter not only allows a power factor of $\cos \phi = 1$ to be achieved, but also allows the wattless component

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of other loads to be compensated for in the mains system, at least as far as power margins are concerned. If the active front end is equipped with an input filter, virtually harmonic-free operation from the mains system is also possible.

A diode front end has the disadvantage that four-quadrant operation is not possible without further complexity. The additional complexity is that a break chopper is required for generator operation, by means of which the generated energy is converted into heat in a breaking resistance. The use of 12-pulse and 24-pulse diode front ends means that 5th, 7th, 11th and 13th harmonics, and 5th, 7th, 13th, 23rd and 25th harmonics, respectively, are suppressed. In the 24-pulse embodiment of the diode front end, the complexity on the input side is twice that of the 12-pulse embodiment of the diode front end, which means that it is not just the space requirement that increases.

An active front end has the disadvantage that the 5th, 7th, 11th and 13th, etc. harmonics occur, depending on the number of pulses, whose amplitudes, can at least be minimized by means of an optimized pulse pattern. Furthermore, the active front end is more complex than a diode front end owing to the number and configuration of the components. Since, in design terms, the active front end corresponds to the machine-side self-commutated pulse-controlled converter, a voltage intermediate circuit converter with an active front end occupies a larger amount of space than a voltage intermediate circuit converter with a 12-pulse diode front end.

The invention is now based on the object of specifying a voltage intermediate circuit converter whose input

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converter is designed such that the harmonics which occur on the mains system side are kept as low as possible, with little complexity.

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This object is achieved according to the invention by the characterizing features of claim 1.

Since the converter elements of the 12-pulse input
5 converter are each self-commutated pulse-controlled
converters, the advantages of a diode front end are
combined with those of an active front end. This means
that the harmonic currents of the 5th, 7th, 17th and 19th
harmonics are suppressed on the mains system side of the
10 voltage intermediate circuit converter without the
optimized pulse patterns of the self-commutated pulse-
controlled converters being optimized to these said
harmonics. Since the two converter elements are in the
same operating state, their pulse patterns are the same.
15 This optimized pulse pattern can now be optimized such
that the amplitudes of the harmonic currents of the 11th,
13th, 25th, etc. harmonics are minimized.

A further advantage of this input converter according to
20 the invention for a voltage intermediate circuit
converter is evident at very high voltages. The
converters for standard medium voltages have two or more
active converter devices connected in series for a
voltage value above 3.3 kV. Since the input converter
25 according to the invention has two identical self-
commutated pulse-controlled converters, which are
connected electrically in series, the number of converter
elements connected in series is equal to or one less than
the number of machine converters connected in series.
30 With the standard medium voltage of 4.16 kV, the input
converter of a voltage intermediate circuit converter
according to the invention has precisely the same number
of active converter devices as an input converter in the
active front end configuration. Low blocking-capability
35 semiconductor switches, which can be operated at a higher

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switching frequency or can be used at higher current
levels, can be used as the active conductor

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devices, with precisely the same number connected in series. The design of the phase modules is simpler and more space-saving, with the number of items connected in series being reduced by one.

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Advantageous embodiments of the input converter can be found in the dependent claims 2 to 6.

In order to explain the invention in more detail, reference should be made to the drawing, which shows one embodiment of the input converter according to the invention, schematically, and in which:

Figure 1 shows a block diagram of a standard version of a voltage intermediate converter of this generic type,

Figure 2 shows a block diagram of an input converter according to the invention for a voltage intermediate circuit converter as shown in Figure 1, and

Figures 3-5 each show one phase module of a machine converter of a voltage intermediate circuit converter with 1, 2 and 3 items connected in series.

Figure 1 shows a block diagram of a standard version of a voltage intermediate circuit converter of this generic type with a 12-pulse input converter 2. The two converter elements 4 and 6 of this input converter 2 are each 6-pulse diode rectifiers. Each converter element 4 or 6 is linked on the DC-side to a respective capacitor 8 or 10 in a voltage intermediate circuit 12. Since these two capacitors 8 and 10 are connected electrically in series, this voltage intermediate circuit 12 has three potentials C, M and D. Furthermore, this voltage intermediate circuit converter has a machine converter 14, to whose AC-side outputs R, S, T a three-phase machine 16 is connected. On the DC-side, this machine converter 14 is

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electrically conductively connected to the three potentials C, M and D of the voltage intermediate

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circuit 12. High-voltage insulated gate bipolar transistors (HV-IGBTs) are provided as active converter devices for the machine converter 14. The machine converter 14 uses three-point switching. The converter 5 elements 4 and 6 of the input converter 2 are

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electrically conductively connected on the AC-side to a respective secondary winding 18 or 20 of a three-winding transformer 22. On the primary side, this three-winding transformer 22 is linked to a three-phase mains system 24.

Figure 2 shows a block diagram of an advantageous embodiment, according to the invention, of an input converter 2. This input converter 2 has respective self-commutated pulse-controlled converters 4_1 and 6_1 as the converter elements 4 and 6, respectively. These two pulse-controlled converters 4_1 and 6_1 use three-point switching in the same way as the machine-side three-point pulse-controlled converter 14, with HV-IGBTs likewise being used as the active converter devices. On the AC-side, the connections U1, V1, W1 of the self-commutated pulse-controlled converter 4_1 are linked to the secondary winding 18 of the three-winding transformer 22. On the AC-side, the connections U2, V2, W2 of the self-commutated pulse-controlled converter 6_1 are connected to the secondary winding 20 of the three-winding transformer 22.

This illustration in Figure 2 also shows the voltage intermediate circuit 12 in more detail. The two capacitors 8 and 10 of this voltage intermediate circuit 12 are each subdivided into three capacitor elements 8_1 , 8_2 , 8_3 and 10_1 , 10_2 , 10_3 . In this case, the two capacitor elements 8_2 , 8_3 and 10_2 , 10_3 are connected electrically in series, and this series circuit is then connected electrically in parallel with the respective capacitors 8_1 and 10_1 . The junction point between the two series-connected capacitors 8_2 , 8_3 and 10_2 , 10_3 form a medium-voltage potential M1 or M2, respectively, for the respective three-point pulse-controlled converters 4_1 and

6₁. These two series circuits of capacitor elements 8₂, 8₃
and 10₂, 10₃ are also connected electrically in series.
The junction point between

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these two series circuits is connected to the central voltage M of the voltage intermediate circuit 12. Since the capacitors 8 and 10 in the voltage intermediate circuit 12 are each subdivided into a number of capacitor elements 8₁, 8₂, 8₃ and 10₁, 10₂, 10₃,

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the capacitor elements 8_1 and 10_1 can be physically associated with the machine converter 14, and the capacitor elements 8_2 , 8_3 and 10_2 , 10_3 can be physically associated with the self-commutated pulse-controlled converter 4_1 , 6_1 in the input converter 2.

Figure 3 shows a phase module of the machine converter 14, which has four active converter devices T1, T2, T3 and T4 using three-point switching. Each active converter device T1 to T4 has only one semiconductor switch, in particular an HV-IGBT. The number of series connected items in this embodiment is therefore one. This phase module can accommodate a maximum DC voltage U_{ZK} of 3.8 kV between its DC potentials C and D. This DC voltage U_{ZK} is produced by the input converter 2. Since the two converter elements 4_1 and 6_1 are identical and are connected electrically in series on the DC-side, each converter element 4_1 and 6_1 produces half the intermediate circuit voltage U_{ZK} , amounting to 1.9 kV. However, since the phase module has twice the withstand voltage, low blocking-capability semiconductor switches can be used, in comparison to the phase module of the machine-side three-point pulse-controlled converter 14. These low blocking-capability HV-IGBTs can be operated at a higher switching frequency, or at a higher current level.

Figure 4 shows a phase module, whose active converter devices T1 and T4 each have two semiconductor switches, in particular HV-IGBTs. In this case, the number of items connected in series is 2. A maximum DC voltage U_{ZK} of 6.8 kV can occur between the DC potentials C and D. In a voltage intermediate circuit converter as shown in Figure 1, having an input converter 2 according to the invention, the phase modules of the machine-side three-

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point pulse-controlled converter 14 are designed as shown
in Figure 4, and the phase modules of the

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converter elements 4_1 and 6_1 in the input converter 2 are designed as shown in Figure 3.

Figure 5 shows a phase module whose active converter
5 devices T1 to T4 each have three semiconductor switches,

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in particular HV-IGBTs. The number of these active converter devices connected in series is three. With this phase module, with three items connected in series, it is possible for a maximum DC voltage U_{zk} of 10 kW to be
5 dropped between or across the potentials C and D. In a voltage intermediate circuit converter for a standard medium voltage of 6 kV, the phase modules of the machine converter 14 are designed as shown in Figure 5, and the
10 phase modules of the converter elements 4_1 and 6_1 in the input converter 2 are designed as shown in Figure 4.

The number of items connected in series in the converter elements 4_1 and 6_1 in comparison to the number of items connected in series in the machine converter 14 is thus
15 one less beyond a standard medium voltage of 3.3 kV. The phase modules of the converter elements 4_1 and 6_1 are therefore less complex than the phase modules in the machine converter 14. In a voltage intermediate circuit converter for the medium voltage of 4.16 kV, the number
20 of semiconductor switches in the two converter elements 4_1 and 6_1 in the input converter 2 is equal to the number of semiconductor switches in the input converter 2 in the active front end embodiment. This means that, 5th, 7th, 17th and 19th harmonics are eliminated just by the
25 circuitry, without having to increase the number of semiconductor switches.